National Program 101 Food Animal Production
Annual Report for 2012

Introduction

The USDA-ARS National Program for Food Animal Production (NP101) had another productive and dynamic year in 2012. Notable highlights include the review of each unit's project plans through the Office of Scientific Quality Review (OSQR). The review process showed that the research objectives for NP101 were very well supported by the OSQR review panels and this effort has resulted in excellent project plans going forward in FY2013 for the next research cycle. Project plans for NP101 were developed from information gleaned from the NP101 national stakeholder meeting which brought stakeholders and the NP101 research community together to prioritize the scope and direction of research in NP101 and to discuss current and future areas of impact for the food animal industries. These efforts are documented online at: http://www.ars.usda.gov/research/programs/programs.htm?NP_CODE=101 and include: the ***Retrospective Review Panel Executive Summary***; the ***2011 Workshop Program and Summary***; and the ***FY2013-FY2018 Action Plan*** for NP101 which is now in effect as of October 1, 2012.

Food animal products fill a vital role in the diets of people around the world as valuable sources of high quality protein, fatty acids, and minerals. The dramatic improvements in production efficiencies developed and harvested by ARS scientists help ensure international food security and directly impact human health and obesity by reducing the real cost of nutritionally valuable meat, milk, and eggs, making animal products more available to those populations most in need. Ongoing improvements in production efficiencies also continually lessen the environmental impact of meat animal production by reducing grain and forage requirements and lessening the amount of manure produced. These improvements have dramatically reduced the amount of green house gas emissions produced by livestock and will continue to have impact.

The scientific accomplishments of the USDA Agriculture Research Service and National Program 101 are truly remarkable and were again well documented in 2012. NP101 scientists continue to make inroads toward a better understanding of food animal production challenges relating to genomic discovery science and application, growth and production efficiency, lifetime productivity, animal well-being, environmental adaptation, product quality and healthfulness, reduction of feed and energy inputs, enhancements in energy retention, and reduced environmental impact. Application of technologies developed or enhanced by NP101 scientists promise to continue to address the high priority issues for consumers while enhancing the profitability and competitiveness of food animal producers across the United States in today's very competitive global agriculture community.

During FY 2012, 96 full-time scientists working at 10 locations across the United States were actively engaged in more than 130 independent research projects in the program. New research projects in NP101 were approved through the ARS Office of Scientific Quality Review in 2012, making this the first year of a new five-year implementation plan for these research projects. The gross fiscal year 2012 funding for NP101 was $48 million.

Personnel in NP101

New additions to the NP101 team in 2012 are:

Chad Chase, Clay Center, Nebraska, joined the NP101 team at the U.S. Meat Animal Research Center. Chad was previously located in ARS at Brooksville, Florida.

Jim Neel, El Reno, Oklahoma, joined the NP101 team at the Grazinglands Research Laboratory. Jim was previously located in ARS at Beaver, West Virginia.

Ken Turner, El Reno, Oklahoma, joined the NP101 team at the Grazinglands Research Laboratory. Ken was previously located in ARS at Beaver, West Virginia.

The following scientists retired from the ranks in NP101:

The distinguished record of service of these gentlemen is recognized world-wide and they will be missed in NP101.

Glen Broderick, Dairy Forage Research Center, Madison, Wisconsin.

Mike MacNeil, Ft. Keogh Livestock and Range Research Laboratory, Miles, City, Montana.

Duane Norman, Animal Improvement Programs Laboratory, Beltsville, Maryland.

The following scientists in NP101 received prominent awards in 2012:

Tami Brown-Brandl, Clay Center, Nebraska, received a *Presidential Citation* from the American Society of Agricultural and Biological Engineers.

Jeff Carroll, Lubbock, Texas, was a member of the ARS Your Two Cents Team that won the *2012 USDA Secretary's Honor Award* in the category of Diversity and Inclusion.

Jeff Carroll and **Nicole Burdick Sanchez**, Lubbock, Texas, were co-authors of an abstract that was selected as one of the *President's Picks* for the 2012 Joint Annual Meeting of the American Society of Animal Science, American Dairy Science Association, the Canadian Society of Animal Science, the Asociación Mexicana de Producción Animal, and the Western Section of the American Society of Animal Science.

Hans Cheng, East Lansing, Michigan, received the *2012 Evonik Degussa Award* from the Poultry Science Association.

Larry Cundiff, (retired), Clay Center, Nebraska, was elected to the *USDA-ARS Hall of Fame.*

Kreg Leymaster, Clay Center, Nebraska, received a *Distinguished Alumni Award* from the Ohio State University College of Food, Agriculture and Environmental Services.

Duane Norman, (retired) Beltsville, Maryland, was named the *2011 World Dairy Expo Industry Person of the Year*.

Ken Turner, El Reno, Oklahoma, was awarded the *2012 Merit Award* from the American Forage and Grassland Council for excellence in forage and grassland research.

Paul Van Raden, Beltsville, Maryland, received the *2012 Journal of Dairy Science Most Cited Award* from the American Dairy Science Association.

Curt Van Tassell, Beltsville, Maryland, received the 2012 *American Jersey Cattle Association and National All Jersey Award for Meritorious Service*.

Curt Van Tassell, Beltsville, Maryland, received the *2012 ADSA J.L. Lush Award for Animal Breeding and Genetics.*

Curt Van Tassell and **Tad Sonstegard**, Beltsville, Maryland, were co-recipients of the *2012 Illumina Greater Good Initiative for Research*.

Tommy Wheeler, Clay Center, Nebraska, received the *AMSA Signal Service Award*, "In recognition of devoted service and lasting contributions to the meat industry and to the American Meat Science Association."

Tommy Wheeler, Clay Center, Nebraska, was awarded the *ARS Senior Scientist of the Year* for the Northern Plains Area.

George Wiggans, Beltsville, Maryland, was elected an *ADSA Fellow for 2012*.

The quality and impact of NP101 research was further evidenced in 2012 by following:

- Over 150 refereed journal articles published
- Over 100 invited presentations at national and international symposia
- Application for one new patent
- Fourteen new cooperative research and development agreements with stakeholders
- Thirty two new scientific technologies developed relating to genomics and other research, and
- Administration or development of 13 web sites for academia or stakeholders

In 2012 NP 101 scientists participated in research collaborations with scientists in: Australia, Brazil, Canada, China, Denmark, France, Germany, Ghana, India, Iraq, Ireland, Israel, Italy, Kazakhstan, Kenya, Mexico, Netherlands, New Zealand, Pakistan, Romania, Russia, Scotland, South Africa, Spain, Sweden, Switzerland, Tunisia, Turkey, and United Kingdom.

Accomplishments in 2012

This section summarizes significant and high impact research results which address specific components of the FY 2008 – 2012 action plan for the Food Animal Production National Program. Each section summarizes accomplishments of individual research projects in NP101. Many of the programs

summarized for FY 2012 include significant domestic and international collaborations with both industry and academia. These collaborations provide extraordinary opportunities to leverage funding and scientific expertise for USDA - ARS research to ensure international food security by rapidly disseminating technology which enhances the productivity and efficiency of meat and milk production. Improved production efficiencies decrease the real cost of food and animal products and make these products more available to people worldwide.

Causative mutations found affecting dairy cow fertility.
Extensive genotyping of U.S. dairy populations by ARS scientists has revealed portions of the genome that contain five lethal mutations causing embryonic death. ARS scientists in Beltsville, Maryland, discovered the causative mutations underlying two of these recessive lethal mutations in the Holstein and Jersey cattle breeds. The HH1 mutation in Holsteins is a knockout of a gene that causes spontaneous abortion after the first trimester. This work was done in conjunction with the University of Illinois. The JH1 mutation in Jerseys is a knockout of a gene important in regulating proper RNA splicing resulting in spontaneous abortion during the first trimester of pregnancy. These relatively late term abortions are particularly costly, because affected cows would have been confirmed pregnant by the producer and would be receiving management appropriate for pregnant females. The subsequent abortion creates stress for the cow, increases costs, decreases efficiency and delays the onset of the next lactation. DNA tests for both mutations are now available to producers. Results are being used to guide future mating decisions in both breeds, thus increasing reproductive efficiency in dairy cows by preventing embryonic loss.

Genome copy number variation (CNV) affects reproduction, tropical adaptation and metabolism in cattle.
Previously, no links between CNV and phenotype differences in cattle were known. ARS scientists in Beltsville, Maryland, and Clay Center, Nebraska, using next-generation whole genome sequencing, completed the first comprehensive discovery of CNV in cattle in relation to phenotypic differences. Comparison of CNV regions between indicine and taurine cattle DNA samples were linked to genes associated with health and production traits including fertility, parasite resistance, and feed efficiency.In related research, ARS scientists evaluated over 700,000 genome markers in beef cattle for fertility. Evidence of CNV regions was found on all chromosomes associated with reproductive efficiency and a DNA region was identified specific to cattle that fail to conceive meaning that these areas of the genome are associated with cattle infertility. These results were validated in over 300 Bos indicus x Bos taurus pregnant females confirming the negative impact of the CNV related gene deletions. These findings are a major step forward to identify components affecting genetic variation beyond typical mutations, which are not accounted for in current genetic evaluation systems, and will lead to greater genetic insight and greater genetic progress in cattle breeding programs. These results will also enable development of DNA marker tests to improve reproduction and production efficiencies for the beef industry.

Alternatives to conventional antimicrobials for livestock.
Finding novel antimicrobials that kill multi-drug resistant pathogens is a problem world-wide for both the livestock industries and human medicine. In collaboration with Spanish scientists, ARS scientists in Beltsville, Maryland, identified a bacterial cell wall degrading protein from a virus of *Staphylococcus* bacteria that when applied externally binds and kills *Staphylococcus aureus* bacteria. This protein was then fused to lysostaphin; another protein that is lethal for *Staphylococcus aureus* bacteria; and then to a third bacterial cell wall degrading protein. The combination of these three proteins effectively kills both

bovine and human strains of *Staphylococcus aureus*, including multi-drug resistant strains. This 3 protein fusion strategy; to create cell wall degrading enzymes with multiple simultaneous lethal activities; is potentially applicable to any bacteria with externally exposed cell wall components and should enable production of antimicrobials that are highly refractory to resistance while not targeting beneficial strains of bacteria. This novel fusion protein has the potential to effectively treat persistent mastitis on dairy farms and multi-drug resistant *Staphylococcus aureus* (MRSA) in human hospitals and clinics.

Controlling ammonia emissions and increasing nutritional efficiency in dairy cows through diet.
Cows excrete urea nitrogen in urine, which is converted rapidly to ammonia gas and volatized into the atmosphere. Milk urea nitrogen (MUN) testing was developed to help dairy producers and nutritionists evaluate protein levels and nitrogen use efficiency of dairy cattle diets. A large component of protein is nitrogen. ARS scientists at Madison, Wisconsin, determined that MUN is also a reliable indicator of concentrations of urea nitrogen in urine and ammonia emissions from dairy farms. Six feeding trials were analyzed to determine the relationships between feed nitrogen intake, MUN, and ammonia emissions from dairy barns. Ammonia emissions dropped between 10% and 34% when MUN levels decreased relatively; while milk production and animal well-being were maintained. Feeding less dietary nitrogen would save dairy producers approximately $740 million annually in reduced feed protein (nitrogen) costs while reducing the environmental footprint of the dairy industry through reduced ammonia (green house gas) emissions.

Improved genetic progress for poultry breeders using genomic technologies.
Genomic selection of animals based on their DNA provides significant benefits over traditional breeding methods that rely on familial relationships and the collection of performance data. However, genomic selection in poultry has not typically been employed due to genotyping costs, the relative economic value of individual birds, relatively high reproduction rate and relatively short generation interval for poultry. ARS research in East Lansing, Michigan, in collaboration with other scientists at several academic and industry research institutions, compared commercial chickens selected by genomic selection versus traditional selection. Results demonstrate that genomic selection improves breeding accuracies by up to 100% depending on the trait being measured. As costs for genome sequencing and genetic testing continue to decrease, poultry breeders will be able to economically adopt genomic selection and significantly speed genetic progress for a host of economically important traits.

Temperature humidity index as a useful predictor of live performance in heavy broiler chickens.
As the temperature humidity index increases, drastic declines in growth and efficiency occur for heavy broiler chickens. ARS scientists in Starkville, Mississippi found that once building temperatures exceed a surprisingly relatively cool temperature of 20 C (68F) for 49 day old birds, the amount of feed consumed per pound of live weight gain increases dramatically from about 3.0 pounds of feed per pound of gain (which is typical for the last two weeks of production), to in excess of 6 pounds of feed per pound of live weight gain at 27 C (80F); an increase of over 100% in some production systems. This finding was very significant to the poultry industry. However, the relationship between temperature humidity index and performance metrics was found to be non-linear and suggests that a non-linear approach to controlling the thermal environment is more appropriate than current linear techniques to mitigate heat stress and improve live performance. As feed costs escalate, this research underscores the critical need to optimize cooling techniques and ventilation rates to best manage feed conversion

efficiencies in heavy broiler production systems, particularly in warmer climates and warmer periods during the year.

Reducing the risk of ovine progressive pneumonia infection in sheep.
Ovine progressive pneumonia (OPP) is an incurable, slow-acting, wasting disease that affects sheep in most countries, including the United States. It is one of the most costly sheep diseases due to a 20% decrease in lamb weaning weights and greatly increased premature culling or death of infected breeding stock. OPP also affects Bighorn Sheep populations causing death losses and jeopardizing the sustainability of commercial sheep production in the proximity of Bighorn populations. ARS researchers at Clay Center, Nebraska, compared infection rates of sheep with differing forms of a gene known to affect susceptibility to the OPP virus. Infected ewes that were heterozygous for the OPP susceptibility gene were mated to similarly heterozygous rams. Lambs born to these ewes were then tested at 10 months of age for OPP. Lambs with one or two copies of the dominant form of the OPP gene (susceptible) had three times the infection rate (34%) of lambs without the dominant form (11%). Producers can now use DNA testing to reduce the risk of OPP virus infection which will increase productivity and improve the health and well-being of their sheep.

Improving the fertility of stored turkey semen.
Storing turkey semen for periods of time even up to 24 hours has long been a challenging problem for the turkey industry; increasing labor and handling costs, and creating production level inefficiencies compared to other species. ARS scientists at Beltsville, Maryland, discovered that specific components of the sperm membrane (phospholipids, carbohydrates) are altered when poultry semen is stored under hypothermic conditions. Alteration of these membrane components affects the ability of stored sperm cells to fertilize eggs, resulting in the exclusive use of freshly-collected (non-stored) semen for artificial insemination. A new semen extender formulation developed by ARS scientists reduces the sperm membrane alterations and improves the fertility of stored turkey semen from 30% to 85%. This is a significant advancement in semen storage technology for turkey artificial insemination practices which will improve production efficiencies, lower costs, and improve genetic performance.

Chromosomal regions discovered affecting female reproductive performance and sow lifetime productivity in swine.
Reproductive efficiency has a great impact on the success of pork production. Improving reproductive performance and sow lifetime productivity are high priorities for the National Pork Board. To address this challenge, ARS researchers at Clay Center, Nebraska, scanned the genome of over 1,500 female pigs for reproductive performance traits including: age at first estrus, ovulation rate, litter size, pre-weaning mortality, and maternal influence on birth weight. Significant chromosomal regions were identified on every chromosome and accounted for 50% or more of the additive genetic variation in some traits. In related work, excessive weight loss during lactation often has adverse effects on reproductive performance leading to higher culling rates, delayed estrus and compromised production; particularly in first and second parities young sows. The weaning-to-estrus interval (time to rebreeding); a key industry metric used to assess sow productivity; was found to be significantly affected by DNA mutations in three genes known to be involved in fat production. Five markers were identified that predicted variation in weaning-to-estrus interval from -2.6 to +0.4 days. These findings are important because producers typically invest in excess of $350 to develop a young gilt for breeding. Additionally, 20- 30% of all commercial gilts developed fail to complete parity 1 and up to 50% fail to complete parity 3 in some production systems. These results may eventually lead to DNA tests to evaluate the

reproductive potential of replacement gilts prior to incurring development costs to increase the number of females that reach parity 3 or later; which is the minimum threshold for sow profitability in the pork industry.

Exploring the bovine rumen microbiome.
Using "next-generation" DNA sequencing technologies and newly developed bioinformatic pipelines, ARS scientists in Beltsville, Maryland, systematically reviewed the diversity and population dynamics of microbes in the rumen of newborn calves, mature dairy cows, and beef steers. Collectively, 21 phyla, 31 classes, 93 families, 219 genera, and at least 1,079 operational taxonomic units in the rumen were identified. The common rumen microbiome consists of 8 phyla, 11 classes, 15 families, and 17 genera across all cattle sampled. However, the bacterial communities in the rumen of pre-ruminant dairy calves, dairy cows, and beef steers also were clearly distinguishable. For instance, greater abundance of Fibrobacteraceae and Ruminococcaceae (fiber digesting bacteria) in the rumen of beef steers were demonstrated, which may be associated with differences in their diet and likely reflect the need for enhanced fiber-digesting capacity in beef cattle. Results of this work are important in understanding the dynamics of rumen microbial populations in cattle during rumen development and in response to management, genetic, and dietary changes. A better understanding of the rumen microbiome and its interaction with these factors is needed to optimize cattle diets and will provide opportunities to improve feed utilization and production efficiencies for the cattle industries.

Humane euthanasia technique developed for swine.
Swine producers are seeking for improved techniques to humanely euthanize piglets; a high priority for the National Pork Board. ARS researchers in West Lafayette, Indiana, in collaboration with the National Pork Board developed a technique involving a combination of common and readily available gases; nitrous oxide, oxygen, and carbon dioxide. This two-step technique initially anesthetizes (nitrous oxide and oxygen); and then humanely euthanizes a pig (carbon dioxide), virtually without exception when administered properly. Development of this technique for on-farm use will allow pigs to be humanely and efficiently euthanized with minimal cost and oversight. This technique offers an effective efficient alternative to current, often objectionable, euthanasia techniques which are consistently criticized by animal welfare and associated meat industry activist groups.

Yeast supplementation improves adaptation to heat stress and enhances the health of feedlot cattle.
ARS research in Lubbock, Texas, identified yeast products as non-antibiotic alternatives that improve productivity in feedlot cattle by enhancing immune function which in turn lessens the need for conventional antibiotics. Further collaborative research indicated that supplementing yeast products during a period of heat stress improved feed intake and weight gain while maintaining the overall health of the cattle. Further analyses indicate that yeast supplementation appears to mitigate the negative immune response effects of dietary endotoxins in feedlot rations, which are increased in grain during drought years. Mitigating endotoxins improves or maintains immune function and enhances the overall health of feedlot cattle. Collectively, these studies indicate that yeast products as a feed supplement for feedlot cattle improve health and well-being, mitigate dietary endotoxins and reduce the negative effects of heat stress on growth and feed intake. These benefits will improve the economic competitiveness of the feedlot industry through improved efficiencies, lower costs, and enhanced adaptation to heat stress.

Management options for range livestock producers during drought.
Dealing with drought is a major challenge for livestock producers. To provide producers with options to help deal with severe localized drought conditions for range beef cattle producers, ARS researchers at Miles City, Montana evaluated the impact of early weaning calves at 80 days of age on all segments of range livestock production. Early weaning was shown to improve body weight and condition of cows through the subsequent critical winter period, (particularly in young cows, which are generally more adversely affected by drought and body condition); had no effect on heifer calves that were retained for breeding replacements; and improved growth and quality performance of feedlot steers under some management protocols. Early weaning of calves provides range cattle producers with a method to conserve drought limited forages, preserve sensitive rangelands, maintain cow condition and reproductive performance, and minimize the need for significant herd reductions during periods of extreme seasonal drought.

Light source stability increases the accuracy of commercial beef carcass quality grading cameras.
Variation in ambient light sources among beef carcass grading cameras has created grading inconsistencies in packing plants that significantly impact carcass value and create marketing inefficiencies. ARS scientists at Clay Center, Nebraska, collaborated with both the instrument manufacturers and commercial beef processors to develop an accurate predictor of carcass grade for use with both carcass grading cameras typically used in commercial beef packing plants. The predictive formula has been approved by the USDA-Agricultural Marketing Service (AMS) and is being rapidly adopted by the beef packing industry. These efforts will further enhance the accuracy and implementation of instrument grading for fresh beef, increasing product quality, value, and marketing opportunities for the beef industry.